Method and circuit arrangement for the self-testing of a reference voltage in electronic components

The invention relates to a method and a circuit arrangement for the self-testing of a reference voltage in electronic components.

During the production process, but also when operating in the field, integrated circuits need to be tested to ensure they are operating correctly. Because there are many
5   disadvantages to using external testing devices, given that contact has to be made with each chip individually and subsequent testing of the chip under operating conditions is no longer possible, testing circuits built into the chip itself have become an established practice. This method of testing is known by the name BIST (Built-In Self-Test). BIST gives a chip a closed-loop procedure for identifying faults.
10   The circuits are often fitted with internally regulated voltage sources that are used as sources of reference voltages for comparison with voltages or currents within the integrated circuitry belonging to the circuits. These reference-voltage sources are intended to be as insensitive as possible to the effects of temperature and to external power-supply means from which the voltages fluctuate. To enable a test to be made to check that these conditions
15   are being met, it is known for the reference voltage from a source of this kind to be compared with an external reference voltage. This has the disadvantage that has already been described above for BIST, namely that when the chip is operating in the field contact has to be made with it from outside, which involves an unusual amount of circuitry and cost.
                     It is an object of the invention to specify a circuit arrangement for the self-
20   testing of the reference voltage that can be implemented as an on-chip test, i.e. for which no external reference-voltage source is required.
                     In accordance with the invention, this object is achieved by virtue of the features of claims 1 and 2.
                     Under these, the reference voltage is the variable of a function that has an
25   extreme at the point where the selected nominal value of the selected reference voltage is situated. In a self-test, the values of the function are determined in succession for the reference voltage and for two further test voltages that differ from the reference voltage by

only small positive and negative amounts respectively and these values of the function are compared with one another. If the values of the function for the test voltages differ from the value of the function for the reference voltage in the same direction a pass signal is generated, or if not a, fail signal.

5   An associated circuit arrangement comprises a function generator having a function that has an extreme at the point where the selected nominal value of the reference voltage is situated. The input signals to the function generator are the reference voltage and two further test voltages that differ from the reference voltage by only small negative and positive amounts respectively. The output signals from the function generator are fed to

10   sample & hold circuits whose contents are compared in two comparison circuits for comparing the value of the function for the reference voltage with respective ones of the test voltages.

        These and other aspects of the invention are apparent from and will be elucidated with reference to the embodiments described hereinafter.

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        In the drawings:

        The single Figure is a block circuit diagram of a corresponding testing arrangement.

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        What is taken as a basis is a mathematical function that meets the requirement

$$\frac{df(x)}{dx} = 0 \quad \text{where } x = U_{ref.test}$$

where $U_{ref.test}$ = nominal reference voltage.

25   What this means is that the function f, which depends on the reference voltage U_{ref} to be tested, has an extreme at the point where the nominal voltage $U_{ref.test}$ is situated. If, in what follows, two further test voltages are selected that differ from the reference voltage U_{ref} by only a small amount ΔU_{ref}, then the values of the function that can be expected for them are either smaller than the value for the voltage U_{ref} for testing when there is a

30   maximum at the point at which the nominal voltage $U_{ref.test}$ is situated, or are larger than it when there is a minimum at the said point.

        The function $f = (U_{ref})^3 - U_{ref.test}$ for example has a clear minimum value at the point $U_{ref.test}$.

The Figure is a block circuit diagram of a reference-voltage test that operates on the basis according to the invention. In this case, three values are applied in succession to one and the same block (test) that represents the function described above. The output values are stored in respective sample & hold circuits. Once all the values of the function have been

5   determined, the relationships between the results given by the reference voltage U_{ref} and by the minimal shifts by the voltage ΔU_{ref} are analyzed, i.e. they are compared with one another in comparators V. If the two values differ from the value of the function for the reference voltage U_{ref} in the same direction, in the positive direction in the present example, this means that the value for the reference voltage U_{ref} is at the extreme of the function $f(x)$ employed in

10   the block test and the reference voltage is thus at its nominal value $U_{ref.test}$. The result of the test on the reference voltage U_{ref} is then passed on via an AND circuit as a pass signal. Otherwise a fail signal is emitted. This happens if a comparison of the value of the function for the test voltage $U_{ref} + \Delta U_{ref}$ or $U_{ref} - \Delta U_{ref}$ shows it to be larger than the value of the function for the reference voltage U_{ref} and the other value then to be smaller than that for the

15   reference voltage U_{ref}. The comparator circuits may be of any desired form and have a pass or fail signal as an output.

Because of the manufacturing tolerance in the production process, a once-only calibration of the $f(x)$ function in the block test is necessary for each chip.

LIST OF REFRENCE NUMERALS:

V	Comparator
U_{ref}	Reference voltage
ΔU_{ref}	Value of difference from reference voltage
S&H	Sample & hold circuit
pass	Pass signal
fail	Fail signal

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